Effect of socioeconomic status in mortality rates after brain injury: retrospective cohort

DOCUMENT: SAR-2023-004-BH-v01

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Effect of socioeconomic status in mortality rates after brain injury: retrospective cohort

Document version

Version	Alterations
01	Initial version

1 ABBREVIATIONS

- FIM: Functional Independence Measure
- HR: hazards ratio
- SD: standard deviation
- SES: socioeconomic status

2 CONTEXT

2.1 Objectives

To determine the effect of socioeconomic status of the neighborhood on mortality of patients with brain injury.

3 METHODS

The data procedures, design and analysis methods used in this report are fully described in the annex document **SAP-2023-004-BH-v01**.

This analysis was performed using statistical software R version 4.2.3.

4 RESULTS

4.1 Study population and follow up

There initially were 76,665 observations on 19,303 study participants considered for inclusion. After excluding follow up measurements during the COVID-19 pandemic to mitigate confounding on mortality causes there were 51,308 observations left in the study sample. After applying the inclusion criteria for the study period between 2010-01-01 and 2018-12-31 and considering the status at the last available follow up time for each individual a total of 7,415 participants were included in the analysis.

The epidemiological profile of the participant included in the study was a male participant (5,421 (73%)) with an average (SD) age of 45 (20) years. The average (SD) time of follow up was 3.05 (1.94) years.

Races were not homogeneously available in the study population with 4,941 (67%) individuals being white; 3,170 (43%) were single (never married) at the time of injury, and most participants were well educated with 3,366 (46%) at greater than high school level. A total of 4,377 (59%) were employed and 3,466 (48%) participants lived in an urban area.

Table 1 *Epidemiological, demographic and clinical characteristics of study participants.*

Characteristic	N = 7,415
SES quintiles, n (%)	
Prosperous	1,352 (22%)
Comfortable	1,239 (20%)
Mid-Tier	1,124 (18%)
At-Risk	1,168 (19%)
Distressed	1,194 (20%)
Unknown	1,338
Mortality, n (%)	1,004 (14%)
Time of follow up (years), Mean (SD)	3.05 (1.94)
Sex:, n (%)	
Male	5,421 (73%)
Female	1,988 (27%)
Unknown	6
What is your race?, n (%)	
White	4,941 (67%)
Black	1,144 (15%)
Hispanic	952 (13%)
Other	368 (5.0%)
Unknown	10
What is your marital status?, n (%)	
Single (Never Married)	3,170 (43%)
Married	2,595 (35%)
Divorced	921 (12%)
Separated	244 (3.3%)
Widowed	454 (6.1%)
Other	15 (0.2%)
Unknown	16
Age at injury, Mean (SD)	45 (20)

Characteristic	N = 7,415
Unknown	19
Substance Problem Use, n (%)	2,691 (38%)
Unknown	264
Education, n (%)	
Greater Than High School	3,366 (46%)
Less Than High School	1,380 (19%)
High School/GED	2,615 (36%)
Unknown	54
At time of injury, what was your employment status?, n (%)	
Employed	4,377 (59%)
Unemployed	795 (11%)
Other	2,209 (30%)
Unknown	34
Urbanization based on zip code of address at discharge., n (%)	
Suburban	2,191 (30%)
Rural	1,635 (22%)
Urban	3,466 (48%)
Unknown	123
Prior to this injury, has a physician ever told you that you have a seizure disorder?, n (%)	52 (5.6%)
Unknown	6,488
Spinal cord injury:, n (%)	434 (5.9%)
Unknown	19
Cause of injury:, n (%)	
Vehicular	3,327 (45%)
Violence	650 (8.8%)
Falls	2,544 (34%)
Other	873 (12%)
Unknown	21
Primary rehabilitation payor:, n (%)	
Private Insurance	3,872 (52%)
Public Insurance	2,916 (39%)
Other	600 (8.1%)
Unknown	27
Residence after rehab discharge:, n (%)	
Private Residence	5,857 (79%)
Other	1,537 (21%)
Unknown	21
Days From Injury to Rehab Discharge, Mean (SD)	46 (37)
FIM Motor at Discharge:, Mean (SD)	64 (18)
Unknown	107
FIM Cognitive at Discharge:, Mean (SD)	23 (7)
Unknown	34

The observed overall mortality was 13.5% in the study period. The distribution of cases appear homogeneous across SES quintiles (Figure 1), ranging from 10.6% to 13.5%. We will test the effect of SES quintiles on the hazard rate in the next section. See also Figure A2 in the appendix for the distribution of sexes in each SES quintile in the study population.

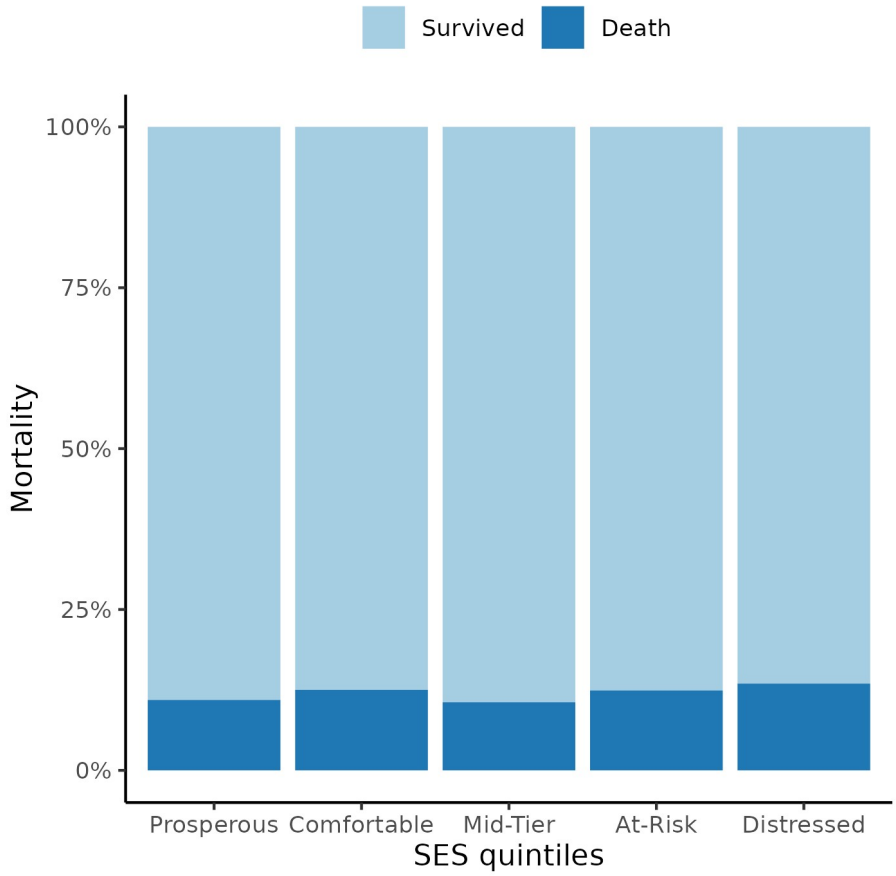

Figure 1 *Proportion of cases per SES quintiles.*

4.2 Effect of SES on mortality

The previous seizure disorder diagnosis was missing for most of the study population and was not included in the model as a covariate to preserve study power. After excluding participants with missing data from other variables a total of 5,756 complete cases were available for analysis. The cause of injury and both FIM scales were removed from the model due to violations to the proportional hazards assumption (see Figure A4 in the appendix for the Schoenfeld residuals and p-values for each variable in the full model).

The survival curves of both sexes by SES quintiles can be seen in Figure 2. Overall, the distressed neighborhoods appear to have a lower survival probability then other neighborhoods. This appears to be true for both sexes, and males had a higher risk of dying than females in all neighborhoods. This plot was cropped at 50% survival for presentation purposes, see Figure A3 in the appendix for an uncropped version.

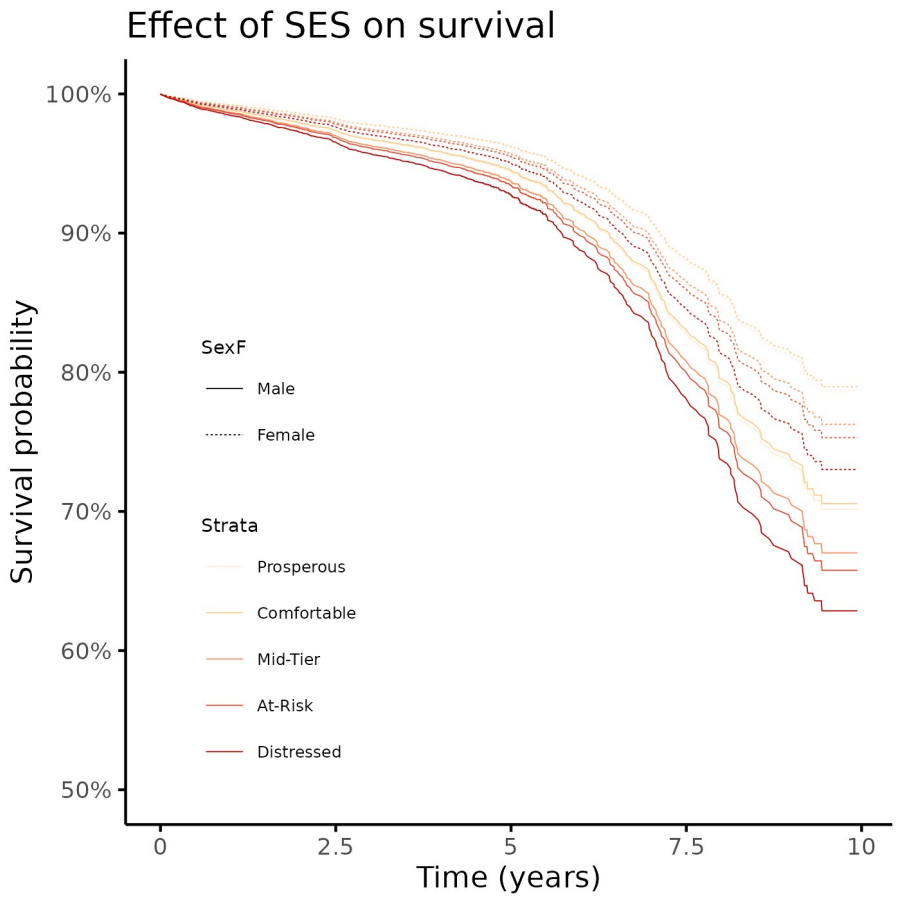

Figure 2 *Survival of participants, by sex and by SES quintiles.*

When considering only the crude effect of SES on mortality neighborhood to which the individuals were discharged was associated with mortality (Table 2). Participants who were discharged to an at-risk neighborhood had increased chance of dying (HR = 1.29, 95% CI = 1.02 to 1.64), when compared to those discharged to a prosperous neighborhood. Participants discharged to a distressed neighborhood also had a higher mortality risk (HR = 1.35, 95% CI = 1.08 to 1.70), when compared to those discharged to a prosperous neighborhood.

Table 2 *Effect of SES on mortality; HR estimates were adjusted for sex, race, age, substance abuse, education, employment status, urbanization, spinal cord injury, rehabilitation payer, residence after rehab discharge and days from injury to discharge.*

Characteristic	HR	95% CI	p-value	HR	95% CI	p-value	HR	95% CI	p-value
SES quintiles									
Prosperous	—	—		—	—		—	—	
Comfortable	1.18	0.94 to 1.49	0.157	0.98	0.78 to 1.25	0.892	0.98	0.74 to 1.30	0.885
Mid-Tier	1.00	0.78 to 1.27	0.979	1.13	0.88 to 1.46	0.349	1.06	0.78 to 1.45	0.693
At-Risk	1.29	1.02 to 1.64	**0.031**	1.18	0.92 to 1.51	0.183	1.30	0.97 to 1.74	0.076
Distressed	1.35	1.08 to 1.70	**0.009**	1.31	1.02 to 1.68	**0.033**	1.23	0.91 to 1.66	0.178

After controlling for all relevant covariates, this effect can only be consistently detected for the distressed neighborhoods, that exhibit a 31% increased risk of dying than prosperous neighborhoods (HR = 1.31, 95% CI = 1.02 to 1.68). The point estimates for all adjusted estimates of SES effect range from 0.98 to 1.31, relative to the prosperous neighborhood, and that represents a narrower range of point estimates than the crude estimates (from 1.00 to 1.35).

When considering only late deaths the SES effect is not significantly associated with mortality, and estimates relative to a prosperous neighborhood range from 0.98 to 1.30 (which is an even narrower range than the crude estimates). The adjusted estimates of all-time mortality can be compared with late mortality where in all neighborhoods the CI of the adjusted estimate is contained within the late death CI's, except for mid-tier and distressed neighborhoods that exceed the respective upper ranges of confidence by a diminute margin (presumably due to precision and study power). The respective point estimates in most cases do not change by a large amount, where most differences fall under 0.1 HR, with the exception of at-risk neighborhoods. In the latter both the difference and the CI indicate higher estimates which, although not consistently detectable, is in line with the crude estimate for these neighborhoods, which has a difference of 0.12 HR. It can be concluded that effect of SES on the risk of late death is not substantially different from all-time death in the study population, after controlling for all covariates.

5 OBSERVATIONS AND LIMITATIONS

Recommended reporting guideline

The adoption of the EQUATOR network (http://www.equator-network.org/) reporting guidelines have seen increasing adoption by scientific journals. All observational studies are recommended to be reported following the STROBE guideline (von Elm et al, 2014).

6 CONCLUSIONS

The epidemiological profile of the study participant is an 31 years old white male, that has greater than high school level of education, is actively employed and lives in an urban setting.

There appears to be a crude effect of SES on mortality, where participants that were discharged to either a comfortable or a distressed neighborhood had increased risk of death when compared to those discharged to a prosperous neighborhood. After controlling for other variables there is no association between SES and mortality.

Both early deaths and late deaths appear to occur at similar rates across all neighborhoods.

7 REFERENCES

- **SAP-2023-004-BH-v01** – Analytical Plan for Effect of socioeconomic status in mortality rates after brain injury: retrospective cohort
- von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg. 2014 Dec;12(12):1495-9 (https://doi.org/10.1016/j.ijsu.2014.07.013).

8 APPENDIX

8.1 Exploratory data analysis

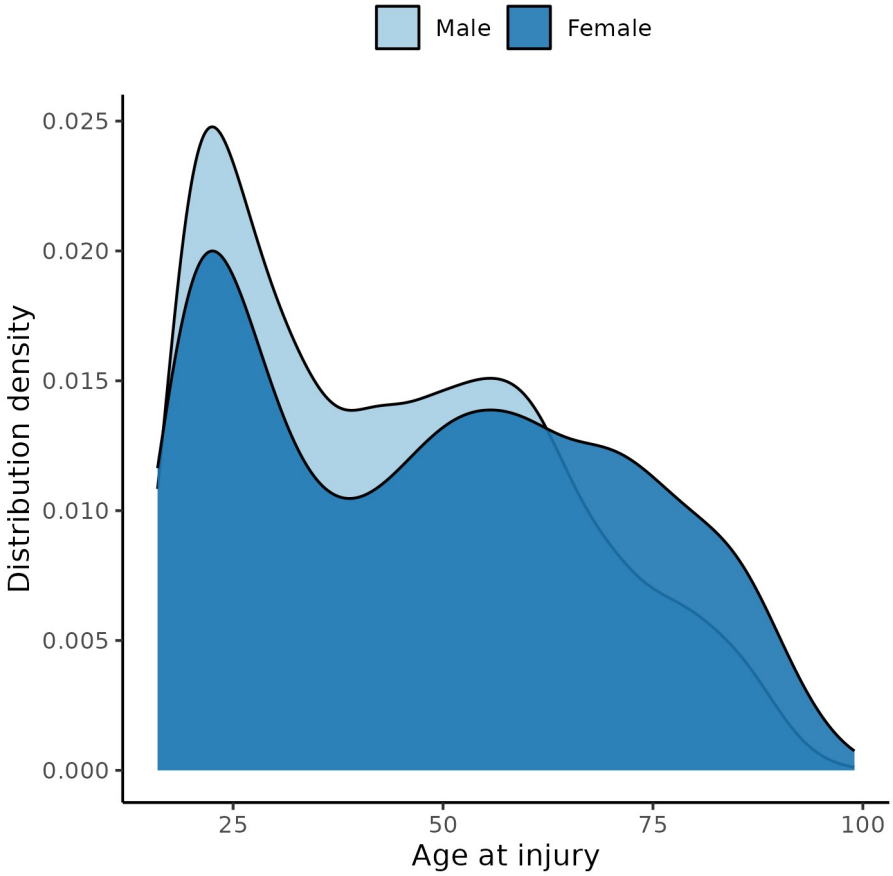

Figure A1 *Distribution of age in the study population.*

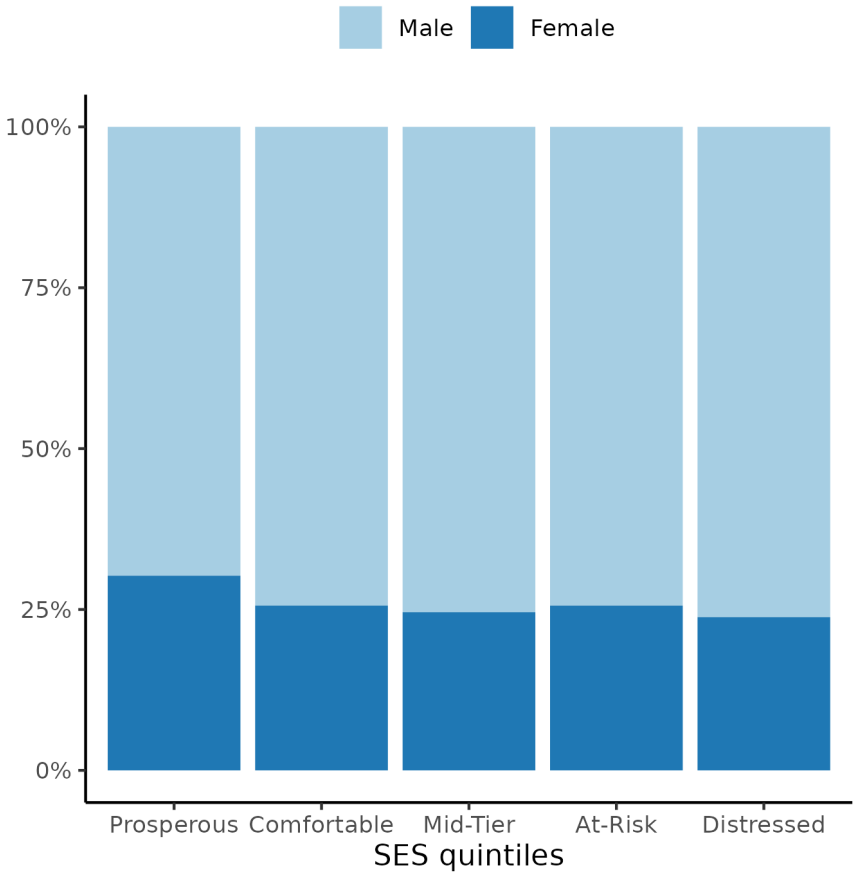

Figure A2 *Distribution of SES in the study population.*

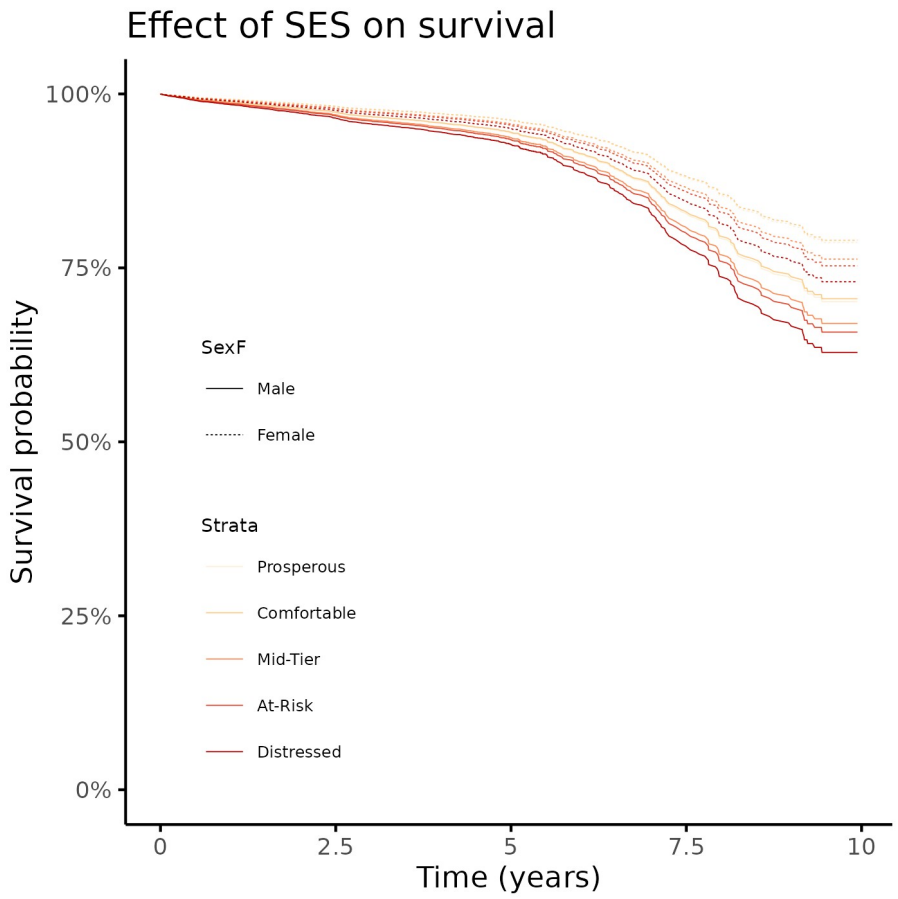

Figure A3 *Alternative version of figure 2.*

8.2 Modeling strategy

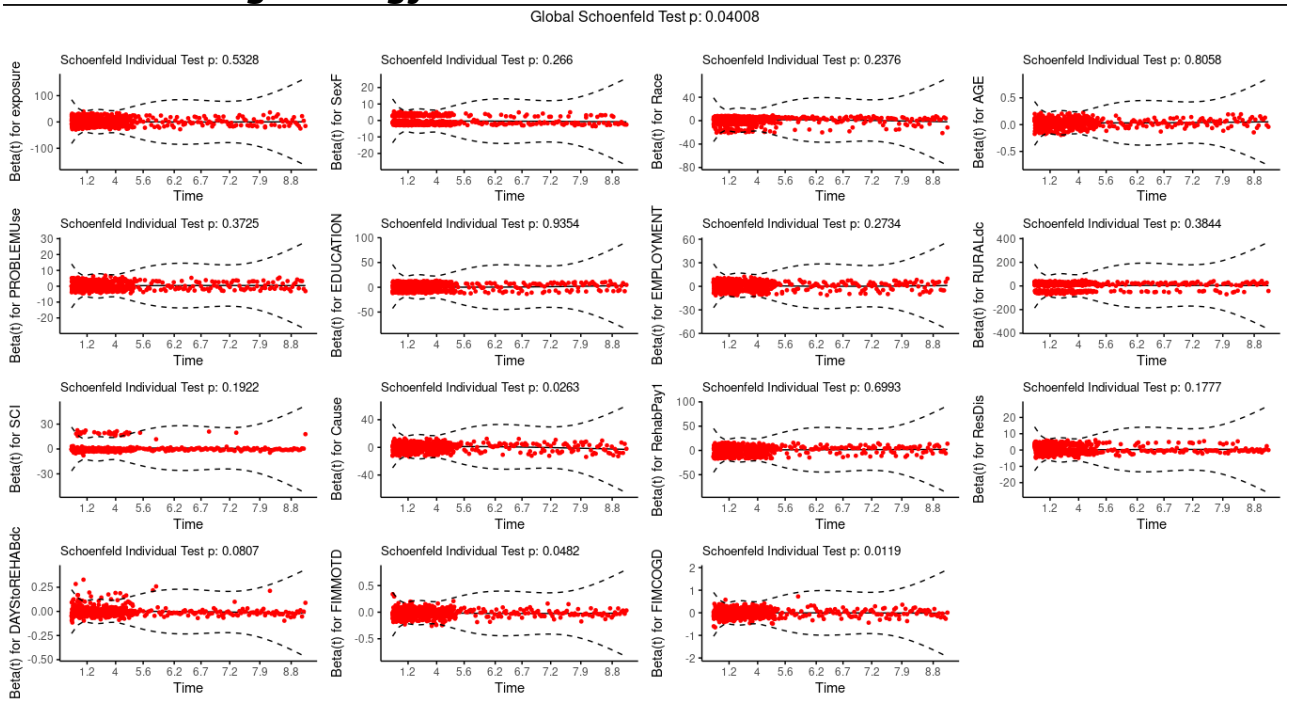

Figure A4 *Schoenfeld residuals for the full model.*

Table A1 *Alternative version of Table 2, showing effects from all covariates included in the model.*

Characteristic	HR	95% CI	p-value	HR	95% CI	p-value	HR	95% CI	p-value
SES quintiles									
Prosperous	—	—		—	—		—	—	
Comfortable	1.18	0.94 to 1.49	0.157	0.98	0.78 to 1.25	0.892	0.98	0.74 to 1.30	0.885
Mid-Tier	1.00	0.78 to 1.27	0.979	1.13	0.88 to 1.46	0.349	1.06	0.78 to 1.45	0.693
At-Risk	1.29	1.02 to 1.64	**0.031**	1.18	0.92 to 1.51	0.183	1.30	0.97 to 1.74	0.076
Distressed	1.35	1.08 to 1.70	**0.009**	1.31	1.02 to 1.68	**0.033**	1.23	0.91 to 1.66	0.178
Sex:									
Male				—	—		—	—	
Female				0.68	0.57 to 0.81	**<0.001**	0.66	0.53 to 0.81	**<0.001**
What is your race?									
White				—	—		—	—	
Black				0.81	0.64 to 1.02	0.073	0.82	0.62 to 1.09	0.171
Hispanic				0.61	0.44 to 0.84	**0.003**	0.70	0.47 to 1.03	0.068
Other				0.72	0.48 to 1.09	0.118	0.78	0.49 to 1.24	0.293
Age at injury				1.04	1.04 to 1.05	**<0.001**	1.04	1.04 to 1.05	**<0.001**
Substance Problem Use									
No				—	—		—	—	
Yes				1.23	1.02 to 1.47	**0.029**	1.25	1.00 to 1.55	**0.047**
Education									
Greater Than High School				—	—		—	—	
Less Than High School				1.23	0.98 to 1.54	0.070	1.25	0.96 to 1.63	0.096
High School/GED				1.36	1.15 to 1.62	**<0.001**	1.29	1.05 to 1.59	**0.016**
At time of injury, what was your employment status?									
Employed				—	—		—	—	
Unemployed				1.82	1.38 to 2.41	**<0.001**	1.77	1.28 to 2.46	**<0.001**
Other				2.03	1.65 to 2.49	**<0.001**	1.91	1.49 to 2.43	**<0.001**
Urbanization based on zip code of address at discharge.									
Suburban				—	—		—	—	
Rural				1.01	0.81 to 1.27	0.921	1.15	0.88 to 1.50	0.307
Urban				1.09	0.90 to 1.31	0.378	1.11	0.88 to 1.39	0.390
Spinal cord injury:									
No				—	—		—	—	
Yes				1.22	0.87 to 1.72	0.257	1.36	0.91 to 2.05	0.134
Primary rehabilitation payor:									

Characteristic	HR	95% CI	p-value	HR	95% CI	p-value	HR	95% CI	p-value
Private Insurance				—	—		—	—	
Public Insurance				1.40	1.16 to 1.69	**<0.001**	1.54	1.23 to 1.94	**<0.001**
Other				1.16	0.80 to 1.66	0.434	1.32	0.88 to 2.00	0.182
Residence after rehab discharge:									
Private Residence				—	—		—	—	
Other				1.70	1.44 to 2.01	**<0.001**	1.40	1.13 to 1.73	**0.002**
Days From Injury to Rehab Discharge				1.00	1.00 to 1.01	**0.020**	1.00	1.00 to 1.00	0.638

8.3 Availability

All documents from this consultation were included in the consultant's Portfolio.

The portfolio is available at:

https://philsf-biostat.github.io/SAR-2023-004-BH/

8.4 Associated analyses

This analysis is part of a larger project and is supported by other analyses, linked below.

Migration patterns in a cohort of individuals with brain injury in the US

https://philsf-biostat.github.io/SAR-2023-016-BH/

Sensitivity of mortality rates to imputation of missing socioeconomic data after brain injury: cohort study

https://philsf-biostat.github.io/SAR-2023-017-BH/

8.5 Analytical dataset

Table A2 shows the structure of the analytical dataset.

Table A2 *Analytical dataset structure*

id	exposure	outcome	Time	SexF	Race	Mar	AGE	PROBLEMUse	EDUCATION	EMPLOYMENT	RURALdc	PriorSeiz	SCI	Cause	RehabPay1	ResDis	DAYStoREHABdc	FIMMOTD	FIMCOGD
1																			
2																			
3																			
...																			
N																			

Due to confidentiality the data-set used in this analysis cannot be shared online in the public version of this report.